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NATURAL HISTORY MUSEUM OF
LOS ANGELES COUNTY



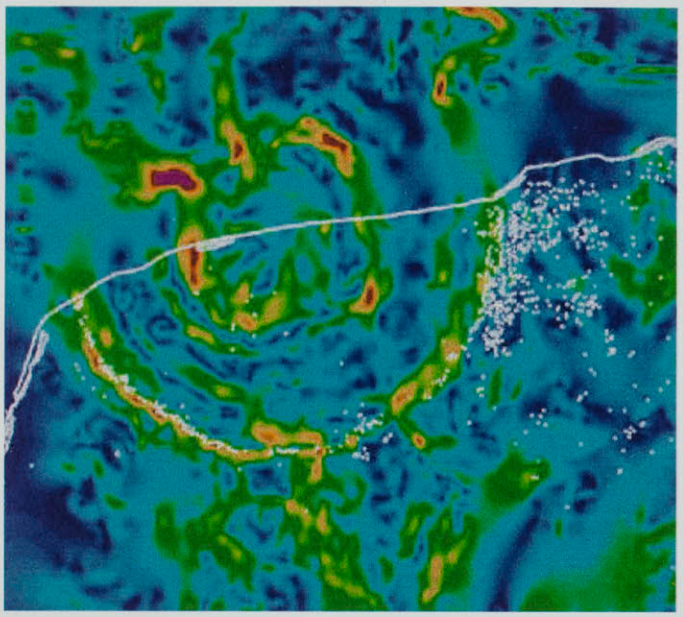
NIGHT COMES TO THE CRETACEOUS

THE DINOSAURS WERE AMONG the most successful creatures ever to live. They reigned for 160 million years, far longer than the mere several million that species of our genus *Homo* have existed. But after having survived for so long, suddenly, in an instant of geologic time, the giant reptiles vanished completely and forever from the earth, leaving in their wake the greatest scientific mystery: what killed the dinosaurs?

The mystery deepens when we learn that not only did the dinosaurs become extinct 65 million years ago, but so did 70 percent of all species. Curiously, the crocodiles, turtles, and snakes, which one would have thought were enough like the dinosaurs to have met a similar fate, survived. What could kill every single dinosaur but spare the crocodiles?

Since the time 150 years ago when the dinosaurs were first discovered, scientists struggled to solve this mystery. Glenn Jepsen of Princeton, writing in 1962, surveyed the many theories that had been offered:

> Authors with varying competence have suggested that dinosaurs disappeared because the climate deteriorated (became suddenly or slowly too hot or cold or dry or wet), or that the diet did (with too much food or not enough of such substances as fern oil; from poisons in water or plants or ingested minerals; by bankruptcy of calcium or other necessary elements). Other writers have put the blame on disease, parasites, wars, anatomical or metabolic disorders (slipped vertebral discs, malfunction or imbalance of hormone and endocrine systems, dwindling brain and consequent stupidity, heat sterilization, effects of being warm-blooded in the Mesozoic world), racial old age, evolutionary drift into senescent overspecialization, changes in the pressure or composition of the atmosphere, poison gases, volcanic dust, excessive oxygen from plants, meteorites, comets, gene pool drainage by little mammalian egg-eaters, overkill capacity by predators, fluctuation of gravitational constants, development of psychotic suicidal factors, entropy, cosmic radiation, shift of Earth's poles, floods, continental drift, extraction of the moon from the Pacific Basin, drainage of swamp and lake environments, sunspots, God's will, mountain building, raids by little green hunters in flying saucers, lack of even standing room in Noah's Ark, and paleoweltschmerz.



Serious geologists eliminated the improbable and silly theories and questioned their usual suspects: changes in sea level, geography, and climate. As continents grow and erode, and sea floors divide and spread, and the earth moves closer and then farther away from the sun, sea level, geography, and climate change continually. Geologists thought that perhaps one of these familiar mechanisms, reaching a rare extreme, brought down the great beasts.

Yet in spite of the appeal of the tried and true processes of geologic change, no one could figure out how such slow mechanisms could have caused what seemed to have been a sudden extinction. Finally, as often happens in science, a serendipitous discovery led to the solution. The culprit turned out to be not one of the familiar agents of change but instead a complete stranger that appeared out of nowhere, stayed only long enough to do the deed, and then vanished as suddenly as it had appeared.

This is the way the mystery was solved. In the late 1970s, geologist Walter Alvarez, son of Nobel-Prize-winning physicist Luis Alvarez, was in Italy studying the magnetism of rocks from the Cretaceous and Tertiary Periods. The 65-million-year-old boundary between the two, known as the K-T, marks the point at which the dinosaurs and other species disappeared. In between the Cretaceous and Tertiary rocks lies a pencil-thin layer of red clay. Walter brought back from Italy a specimen that included this boundary clay as well as the rocks on either side of it and showed it to his father.

Physicist Luis Alvarez thought that geologists and paleontologists would be delighted to learn at long last what had killed their dinosaurs, but most were not.

As physicists are wont to do, Luis Alvarez proposed that they try to measure how long the clay layer had taken to form and in that way perhaps find out how long the process of dinosaur extinction had taken. The two decided to use, as a geological clock, the concentration of a rare element called iridium in the clay. When the measurements came back, however, the iridium turned out to be present in levels so high that the clock did not work. Such high amounts of iridium could only have come from a meteorite (compared to earthly rocks, meteorites are enriched in iridium and other platinum-group metals).



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Impact on Earth, by Don Davis. Acrylic on gessoed masonite, 18 by 24 inches.

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Horizontal gradient map of gravity anomalies over a large impact crater, named Chicxulub after a town near its center. The coastline of the Yucatán peninsula is shown as a white line, and white dots represent the locations of water-filled sinkholes called *cenotes*, many of which are associated with the largest gravity gradient features. The origin of the cenote ring remains uncertain, but its link to the underlying buried crater seems clear. Image based on measurements taken by Petróleos Méxicanos, several Mexican universities, and the Geological Survey of Canada; courtesy Geological Survey of Canada.

COVER: *Meteorite with Pterosaur*, by Douglas Henderson. Pastel, 17 1/2 by 24 1/2 inches. Copyright 1989, Douglas Henderson

Blinded, frozen, and starved, the dinosaurs and the other victims never had a chance.

The Alvarezes came up with the theory that 65 million years ago a meteorite the size of Mt. Everest, traveling at 100,000 miles per hour, had collided with the earth, generating an explosion equivalent to the detonation of 100 million megatons of TNT and releasing far more energy than the discharge of all of the world's nuclear arsenal at the height of the Cold War would have produced. According to the Alvarezes, this colossal impact threw up a vast cloud of dust and debris that blocked the sun, caused a global deep-freeze, stopped photosynthesis, and destroyed the food chain. Blinded, frozen, and starved, the dinosaurs and the other victims never had a chance.

PHYSICIST LUIS ALVAREZ thought that geologists and paleontologists would be delighted to learn at long last what had killed their dinosaurs, but most were not. The theory violated two fundamental and related tenets of the earth sciences—the first, that change is gradual and not catastrophic, and the second, that extraterrestrial objects leave no significant mark upon our planet.

It took nearly 15 years, and a bitter debate, for the Alvarez theory to prevail. During this time its proponents produced a huge volume of supporting data. High iridium levels were found not just in Italy but in well over 150 K-T boundary sites around the world. Many K-T sites contained quartz fractured by high-pressure shock, as well as frozen droplets of once-molten rock, which presumably represented congealed impact vapor.

The coup de grace to those who doubted the theory was the discovery in the Yucatán, buried beneath more than half a mile of younger sedimentary rock, of a 105-mile-wide crater exactly 65 million years old. This discovery proved the first half of the Alvarez theory—that an impact had occurred at the time of the K-T change—but not the second, that the effects of the impact killed the dinosaurs and many other species. That has been much harder to demonstrate, though if the impact did not cause the extinction, then surely this is one of the all-time coincidences in the history of the solar system.

A crater, even one buried half a mile deep, is a physical feature that, using geophysical methods to x-ray the earth, can be "seen." But the fossil evidence, on which we must base our interpretations of the history of life, is much harder to decipher. Most animals and plants leave no fossil remains; erosion and other processes remove most of what does become fossilized.

Only about 2,000 articulated bones of dinosaurs have been found anywhere, and only about 340 dinosaur species have been identified, half based on only a single fossilized bone specimen. At only three places in the world do well-exposed, well-studied dinosaur-bearing rocks extend from the Late Cretaceous up to and beyond a well-defined K-T boundary. The best studied are the beds of the Hell Creek Formation near Glendive, Montana (the source of the magnificent *Tyrannosaurus rex* specimen that glowers over the foyer of the Exposition Park museum).

How could scientists determine whether the second half of the Alvarez theory is correct? By finding what predications it makes and then seeing if those predictions are met. If the Alvarezes are right, then the dinosaurs would have been living, oblivious to their impending fate, right up to the moment the meteorite struck, when all would have died in a geologic instant of a few hundred or a few thousand years, never to reappear. The fossil record would show most species not in serious decline for millions of years prior to the K-T transition but rather to have lived right up to it. And no dinosaur remains would be found to have been deposited above the level of the iridium, in Tertiary rocks.

A 3-year collecting effort by geologists and volunteers from the Milwaukee Public Museum led them to conclude that the dinosaurs were not declining before the K-T event; they judged their findings "consistent with an abrupt extinction scenario." Dinosaur fossils have been found at several sites only a short distance below the boundary, and therefore these species must have been alive only a short time before the K-T event. No dinosaur fossils have been confirmed in the sediment or rock layers above the iridium layer. These results corroborate the predictions of the Alvarez theory.

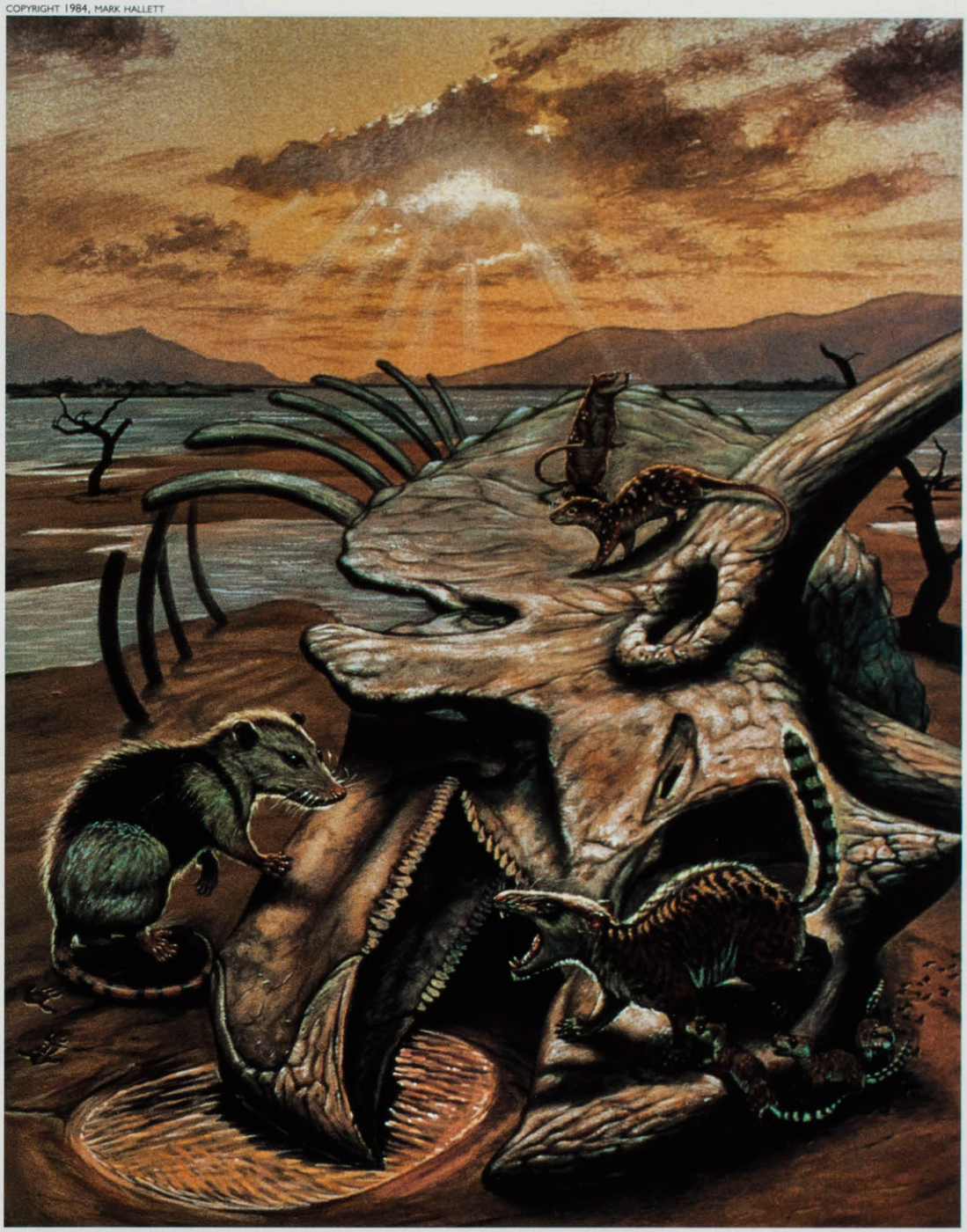
WHAT SAY THE FOSSILS of the other organisms that perished? Plant specialist Kirk Johnson of the Denver Museum of Natural History, like most of his paleontological colleagues, was initially "skeptical of this outlandish theory that attributed the demise of our beloved dinosaurs to some science fiction asteroid." When he extended his collecting to include 25,000 plant specimens, however, he found that 80 percent had become extinct right at the K-T boundary, and he became a believer.

The dinosaurs were not "unfit," just in the wrong place at the wrong time.

Peter Ward of the University of Washington is an expert on the beautiful ammonites that grace natural history museums. After surviving everything that the earth could throw at them for 330 million years, they all perished during the K-T event. At first dubious, Ward had the same experience as Johnson: as he collected more and more specimens, the evidence for the Alvarez theory became ever stronger, until finally he too came to accept it.

Perhaps the most controversial fossil evidence comes from the planktonic foraminifera, the one-celled organisms that float in the sea and then fall to the ocean floor at their death, leaving millions of specimens for future paleontologists to

COPYRIGHT 1984, MARK HALLETT



***Dawn of a New Day*, by Mark Hallett. Gouache, 11 3/4 by 14 3/4 inches.**

find. The majority opinion appears to be that the "forams" were not going extinct in advance of the impact, and that only a handful of species survived it.

My conclusion, having reviewed much of this evidence, is that overall the fossils corroborate the Alvarez theory. Science works not by proving theories correct but by seeing how long they can avoid being proved false. After 15 years and a heap of trying, scientists have not even come close to falsifying the Alvarez theory.

The dinosaurs and the other victims of the K-T impact were not "unfit" but were just in the wrong place at the wrong time. As paleontologist David Raup of the Field Museum has put it, they were afflicted not with bad genes but with bad luck. But their loss was our gain. The disappearance of the dinosaurs left many vacant ecological niches, into which scurried some small, furry, warm-blooded creatures—our mammalian ancestors.

As usual in science, attempting to answer one set of questions raises others. Do we owe our existence to the random trajectory of an asteroid or comet that just happened to cross that of the earth 65 million years ago? So the Alvarez theory says. If a large impact happened once, could it have happened at other times in past earth history? Geologists are trying to find out; the evidence so far collected is tantalizing but inconclusive.

If a giant impact happened 65 million years ago, could one happen in the future? The answer to this question, we know, has to be yes. Though few if any were as large as the dinosaur killer, hundreds, thousands, tens of thousands of asteroids and comets have struck the earth since it formed, and as many remain in our region of space. For the foreseeable future, these objects must continue to strike the inner planets, including the earth. Can we detect the next large meteorite headed our way while it is still out in space, and if so will we have methods of deflecting it away from earth? This too is a subject on which many scientists are working.

JAMES L. POWELL

Dr. Powell, who received his Ph.D. in geochemistry from MIT, is President and Director of the Natural History Museum. This article is drawn from his book, Night Comes to the Cretaceous: Dinosaur Extinction and the Transformation of Modern Geology, *which will be published this spring by W.H. Freeman and Company.*

Experimental Archaeology
STUDENTS EMULATE ANCIENT TOOLMAKERS





When describing or displaying the tools and artifacts of prehistoric peoples, archaeologists are often asked, "How did they make that?" We usually reply by speculating on the basis of available evidence, but sometimes we must say that we really do not know. In summer 1997, four high school students helped to answer the question, at least for certain kinds of ancient bone tools found in the Natural History Museum's archaeology collections.

Working with me and Dr. Thomas Wake, Director of the Zooarchaeology Laboratory at the UCLA Institute of Archaeology, the young scientists studied collections of bone tools recovered from excavations here in southern California. Then they spent 6 weeks making copies of ancient whistles, beads and tubes, awls, and other items, using only the materials available to prehistoric workers.

The students—Anna Kasho (now a freshman at Santa Monica College), Ariel Lawrence (Long Beach Polytechnic High School), Joshua McGuffie (Loyola High School), and Matthew Van Dam (Beverly Hills High School)—began by learning knapping, the ancient art of chipping flints to create a tool. Each became adept enough to make at least a few sharp flakes suitable for cutting meat, hide, or bone, and two learned to make projectile points like those used on spears and arrows.

With their new stone tools, the students manufactured twenty-five objects from pelican, cormorant, and deer bone, starting with the defleshing of the bones, just as ancient toolcrafters would have had to do. The researchers documented their work with video and still camera, drawings, and notes. When the experimentally produced artifacts were complete, the team analyzed their tools to determine which were most effective at different tasks and on differing materials.

Dr. April Sievert of Indiana University guided the student researchers through microwear analyses of their tools, using high-powered metallurgical microscopes. By noting the damage, striations, and polish inflicted on the new tools by various work projects, the students were able to produce a comparative collection that can be used to determine if ancient artifacts have been put to similar uses.

With their step by step reproduction of the manufacture of several kinds of tools, the researchers provided information on the time required to make prehistoric artifacts, the difficulties that can be encountered, and the damage and residues left on tools when they are used for different purposes. The students gained new appreciation for the technological skills of ancient Californians, and their work will help archaeologists better understand early technologies from all over the world.

Karen Wise

Dr. Wise is Assistant Curator of Anthropology and an expert in Peruvian archaeology. The project described here was part of the Museum Research Apprenticeship Program (MRAP), which was funded by a National Science Foundation grant to Dr. Wise and Susan K. Lafferty; Dr. Wake's participation was supported by the UCLA Institute of Archaeology.

Much of the student's work was conducted in the Natural History Museum's Bird and Mammal Preparation Room; animal raw materials were provided by Kimball Garrett and John Heyning (Research and Collections, Vertebrate Zoology) and Tim Bovard (Exhibits, Taxidermy).

At UCLA, Richard Leventhal, Director of the Institute of Archaeology, and Glenn Russell, Director of the Lithics Laboratory, gave access to the Teaching and Lithics laboratories; Dr. Russell also provided chert and obsidian raw materials for flint knapping.

Photographs of project participants by Dr. Wise.





MUSEUM ON THE MOVE

GLUCK MOBILES RECEIVE SUPPORT

With a gift of $1.2 million from the Maxwell H. Gluck Foundation, one of the museum's most popular programs will continue. For each of the next 3 years, more than 25,000 elementary school children from the Los Angeles Unified School District will step into the unique educational wonderlands of the Gluck Foundation's Earthmobile and Seamobile.

"Teachers tell us that children who've never shown any interest in science classes become eager to learn more after having visited the Earthmobile or the Seamobile," says Linda Abraham, Acting Chief of Education. "The museum is extremely grateful to the Gluck Foundation for its generous support."

HERPETOLOGIST RETIRES

Robert L. Bezy concluded a distinguished 27-year career with the Natural History Museum in September 1997 when he retired from his position as Curator of Herpetology and chair of the Vertebrate Zoology Program.

Born in Phoenix in 1941, Dr. Bezy spent much of his childhood roaming the irrigation ditches, canals, and desert near his home. He became fascinated with insects, lizards, snakes, and frogs and kept a collection of both live and preserved specimens. By the time he entered high school, he knew he wanted to become a herpetologist.

Dr. Bezy spent the 1960s at the University of Arizona earning both a bachelor's and a doctoral degree. Working as an assistant in the university's collection of amphibians and reptiles, he developed a passion for field and museum work.

After receiving his Ph.D in 1970, Dr. Bezy joined the museum's curatorial staff in the Herpetology section. At that time, the collection of amphibians and reptiles was relatively small; he devoted much of his time at the museum to helping build it into one of the world's major herpetological resources, an effort that was supported by three National Science Foundation grants. He was also an enthusiastic supporter of the museum's public outreach, including the Museum Research Apprenticeship Program for gifted high-school-age scientists.

Dr. Bezy's field work has taken him throughout the southwestern U.S. and to Mexico, Guatemala, Costa Rica, Panama, Australia, Kenya, Namibia, and Botswana. Much of his research has been devoted to studying the systematics and evolution of night lizards (family Xantusiidae; see *Terra* 28(1):29-34) using a variety of approaches from scale counts to DNA sequences. As Curator Emeritus at the museum, he will continue studying DNA evolution in the genus *Xantusia* with Research Associate Kathryn Bolles.

With his family, Bob Bezy has now settled in Tucson, on what he considers "an extended field trip to the deserts I love."

FOUNDATION AND CORPORATE GIVING ENHANCES PUBLIC OUTREACH

In the past months the Natural History Museum has received significant gifts from foundations and corporations that will enable it to maintain and expand several valuable outreach programs during the 1997/1998 fiscal year and to initiate exciting new projects.

- A generous contribution from the S. Oschin Family Foundation will benefit 3,000 children with disabilities through the Museum on Wheels program, in which trained docents use materials from the museum's collections in presentations at special schools, hospitals, and other facilities in the greater Los Angeles area.
- A grant from the Ahmanson Foundation inaugurates Dinosaur Discovery School, a new program for preschoolers and their parents that will foster interest in the natural world and instill the habit of visiting museums.
- The Kenneth T. and Eileen L. Norris Foundation will support Classroom Collections, which brings the benefits of the museum to schools unable to participate in its regular touring program.
- Sustaining grants from the Marlowe Family Trust and the Capital Group Companies will support the museum's planning of major exhibits and new educational programs.
- The AlliedSignal Foundation's most recent contribution to the Natural History Museum will be used to increase educational resources available to the thousands of school children who visit the museum each year.

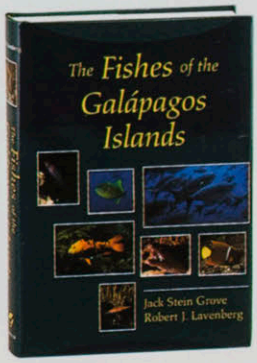
NSF SUPPORTS VERTEBRATE COLLECTIONS CARE

The National Science Foundation has awarded a 2-year grant of $201,500 to computerize the museum's collections of both fishes and amphibians and reptiles. These collections, which represent a significant international research resource, include approximately 7 million specimens as well as ancillary holdings of frozen tissues, skeletons, chromosome slides, photographs, radiographs, and library materials.

In September 1997, work study students from the University of Southern California, supervised by Collections Manager Richard Feeney, began entering data on the collections into four newly purchased Dell computers. When data entry is completed, in fall 1999, researchers from all over the world will have the ability to peruse the collections through their Internet servers

NEW BOOKS BY CURATORIAL EXPERTS

With the publication of their book, *The Fishes of the Galapagos Islands* (Stanford University Press, 1997), Robert J. Lavenberg, Deputy Director for Research and Collections, and Jack Stein Grove provide an important contribution to the literature on the equatorial eastern Pacific Ocean. An au-



continued on page 14

COLD TONGUES, WARM HEARTS
Temperature Regulation in Baleen Whales

A GRAY WHALE DIVES TO THE BOTtom of the shallow Bering Sea off the coast of Alaska, rolls on its side, and then opens its enormous mouth to suck up bottom sediments and the associated shrimplike crustaceans, called amphipods. Closing its mouth, the whale forces water and silt out through its filtering baleen and then feasts upon the amphipods, which remain behind.

The whale's filter feeding not only traps prey, but it also exposes the inner surfaces of the mouth to the frigid polar waters. Although a gray whale's blubber layer effectively insulates it in even the coldest of waters, its immense mouth lacks blubber. Feeding should cause these "warm-blooded" mammals to chill and eventually succumb to hypothermia after just a few meals.

This physiological dilemma is not restricted to gray whales but is shared by other species of baleen whales, which are members of the suborder Mysticeti: all have cavernous mouths to accommodate the maximum amount of baleen filtering surface, and most feed in the cold waters of high latitudes. How do these whales manage to maintain body warmth while feeding?

My study of this quandary grew from the simple observation of a unique pattern of blood vessels in a rare mysticete, the pygmy right whale (see *Terra* 34(4): 6-7). Scattered throughout the tongues of these relatively small baleen whales were a number of "countercurrent heat exchangers," each consisting of a single central artery encircled with a network of veins. A heat exchanger allows the transfer of heat from warm blood coming from the body core in the artery to the adjacent cooler blood returning from an extremity in the veins. Scientists have known for some time that the fins and flukes of whales and dolphins contain countercurrent heat exchangers, but the discovery of this heat-conserving feature in the tongue of a whale was surprising. I wondered if other baleen whales have these structures in their tongues.

The baleen whale most frequently stranded off southern California is the gray whale *(Eschrichtius robustus)*, which migrates along our coastline from its winter mating and calving lagoons off the west coast of Baja California to its summer feeding grounds in the Bering and Chukchi seas. When a gray whale strands locally, its beach-cast carcass is usually transported to the museum's Marine Mammal Laboratory for careful dissection and preservation. In late 1996 and early 1997, my colleague Dr. James Mead and I dissected the vascular system of the tongues of two gray whales that had stranded.

The gray whale's tongue is massive, representing 5 percent of the entire surface area of its body. In the tongues of each of the two young calves we dissected we found numerous countercurrent heat exchangers, all converging at the tongue's base into a bilateral pair of bundles, each with over 50 heat exchangers in parallel arrangement. We called these bundles the *lingual retia*, or tongue network. The lingual retia of these whales are far larger than the heat exchangers associated with their fins and flukes.

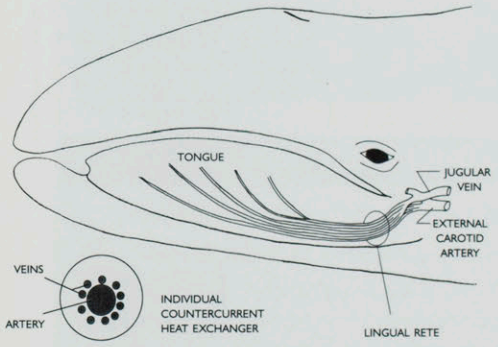




When stranded in January 1997, JJ weighed 1,670 pounds; by year's end, she had grown to well over 15,000 pounds. The photographs on these pages were taken in spring and summer, by Dr. Heyning. The schematic below is courtesy AAAS

In retrospect, it seems incredible that we cetacean anatomists could have overlooked such large and complex structures in previous dissections of baleen whales. Yet because the vascular system is composed of numerous small, thin-walled veins that easily collapse when the large, flaccid tongue is dissected, the lingual retia had escaped notice.

Jim Mead and I had found countercurrent heat exchangers in our tongue dissections, but we lacked the physiological proof that they actually worked to conserve body heat in gray whales. And proof seemed impossible to get: no baleen whales were held in captivity, and free-swimming gray whales were not



likely to have much interest in allowing us to take temperatures readings from inside of their mouths.

Then a widely publicized event provided us with a once in a lifetime opportunity. In January 1997, an orphaned newborn gray whale was found off Marina del Rey. The museum's mammalogy staff helped in the rescue of the calf, which was taken to Sea World in San Diego. There, the youngster—who was named JJ—thrived under expert care. And overnight, we had an opportunity to test our hypothesis.

Heat is transferred into or out of the body because of temperature differentials, and a comparison of a whale's skin surface temperature with the temperature of the surrounding water is a good indicator of heat loss: if there is little difference between the temperature of the skin and that of the water, it is a sign that little heat loss is taking place. On several occasions in spring and summer of 1997, I leaned over JJ's tank at Sea World with an infrared thermometer and took some measurements as she was fed.

As she suckled on her feeding tube, JJ needed to open her mouth to the water only a little way. After about 1 minute of feeding, the temperature of the surface of her tongue was a mere 1° Fahrenheit above that of the surrounding water, and 1° to 4° F below the temperature of her head and neck region.

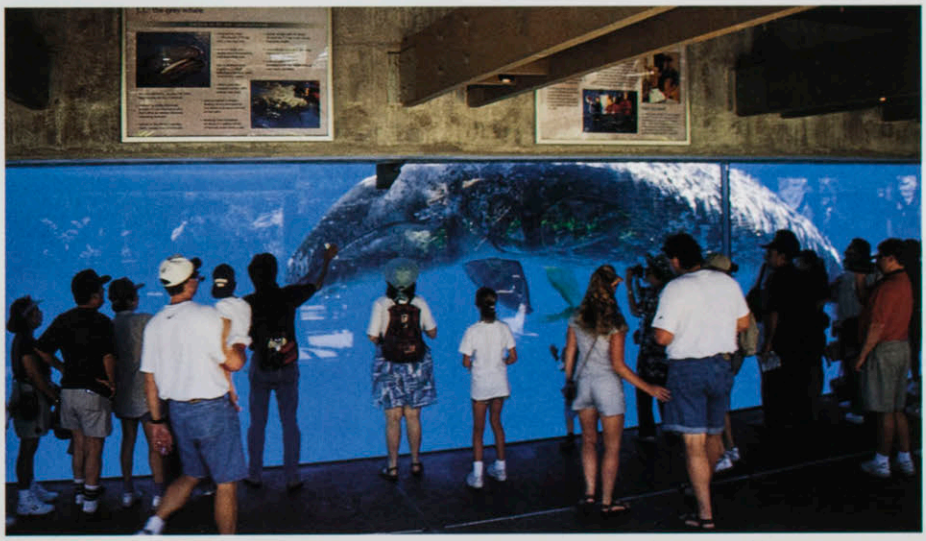
Just as I had predicted, JJ was losing little heat through her tongue. Furthermore, her tongue remained a vivid pinkish color, indicating that the blood vessels there were not simply constricting to conserve heat. Our observations suggest that the lingual retia are extremely efficient: gray whales appear to suffer more heat loss through their body-encasing blubber layer than through the tongue, in spite of the fact that the tongue has far more blood vessels and possesses significantly less insulation.

I've reviewed the scientific literature and believe that countercurrent heat exchangers may be a universal feature in the mouths of baleen whales, although the vascular structures have never been identified as such in other dissections. Our findings suggest that, for all baleen whales, the mouth is a crucial site for the regulation of body temperature during filtration of their prey.

The development of countercurrent heat exchangers in the mouths of baleen whales is probably as important in their evolution as the development of the filtering baleen itself. These two structures have together allowed these mammals to exploit the high productivity of the ocean's coldest waters.

JOHN E. HEYNING

Dr. Heyning is Curator of Mammalogy and Chair of the museum's Vertebrate Zoology Program. His and Dr. Mead's report on gray whale lingual retia was published in the November 7, 1997, issue of Science.



PROGRAMS FOR MEMBERS AND VISITORS

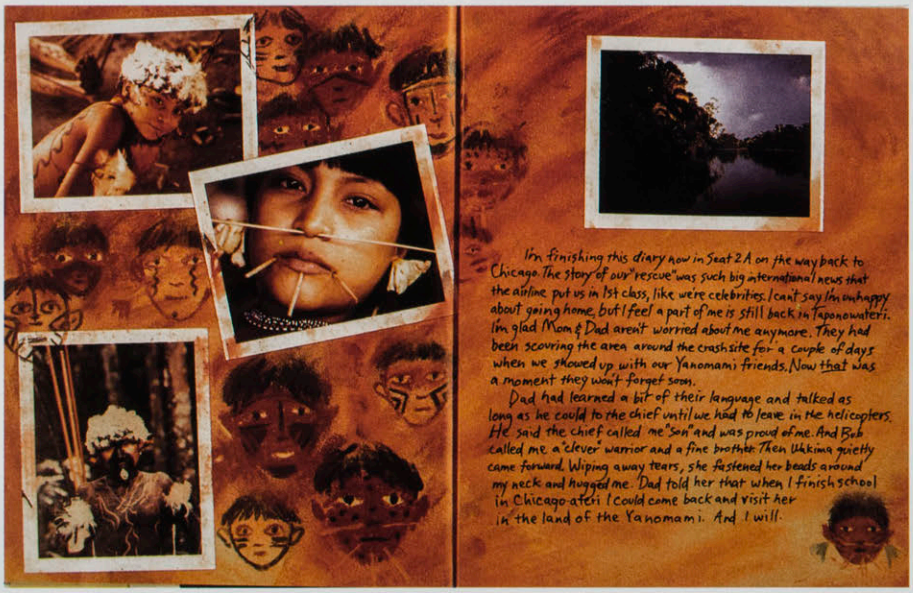
LECTURES & SPECIAL EVENTS

■ AMAZON DIARY

The Jungle Adventures of Alex Winters

Sunday, January 18, 2 p.m., Jean Delacour Auditorium, Museum of Natural History. Children ages 7 and older with accompanying adult

Discover the amazing world of the Yanomami of South America with Hudson Talbott, author of a number of children's books, including *We're Back! A Dinosaur's Story.* A visit to the Yanomami by Mr. Talbott and coauthor Mark Greenberg was the inspiration for *Amazon Diary: The Jungle Adventures of Alex Winters* (G.P. Putnam's Sons, 1996), a fact-based tale of a fictitious sixth grader, Alex Winters, who becomes stranded among the Yanomami. Alex's journal, which he illustrates with drawings and photos, is the basis for *Amazon Diary.* $7 members, $9 nonmembers, $5 students with I.D.



COURTESY HUDSON TALBOTT

La Brea Zoo Lecture Series

■ LA BREA HORSES AND THEIR KIN

Saturday, January 31, 2 p.m., Page Museum

Horses first originated in North America 55 million years ago and underwent most of their evolution on this continent. Yet the wild horses found here today are descendants of domesticated animals brought here by the Spaniards three centuries ago. Why did the horses from Rancho La Brea become extinct at the end of the Pleistocene Ice Age? How many horse species were present in Los Angeles 12,000 years ago? What are their names, and who were their elusive relatives? These and other questions will be discussed by Eric Scott, Paleontology Field Supervisor of the San Bernardino County Museum and long-time Museum Associate of the Page Museum.

Other La Brea Zoo lectures in the coming months include Giant Ground Sloths (Saturday, March 28) and The Artiodactyl ABC's (Saturday, May 30). Individual lecture tickets are $7 members, $9 nonmembers, $5 students with I.D.

ADULT CLASSES

African Dance Workshop

■ LA FETE AU VILLAGE

Saturday, February 14, 10 a.m. to noon, Museum of Natural History. Children ages 12 and up if accompanied by an adult

Come to La Fete au Village (The Party at the Village) and celebrate Black History Month by participating in festive Cameroon dances and learning their meanings. Our teacher is the acclaimed artist Noah Andzongo Michel, who with his dancers, African Labina, received the 1992 Diploma of African Excellence, a top honor in the world of dance; Mr. Michel was named as best choreographer, and his group, best dance troupe. $25 members, $35 nonmembers.

■ BASKET WIZARDRY

Saturdays, February 28 and March 14, 9 a.m. to 4 p.m., Education Classroom, Page Museum

Master basket maker Judy Mulford teaches us to create beautiful, functional baskets using telephone wire (February 28) and palm stalks (March 14). We'll explore various stitches, pattern design, and basket-shaping techniques. Ms. Mulford welcomes students of all experience levels. Fee per class, $55 members, $65 nonmembers.

ADULT FIELD TRIPS

■ THE HEART OF DOWNTOWN

Saturday, February 28, 9 a.m. to noon

Explore the heart of Los Angeles and its kaleidoscope of architectural landmarks on this special walking tour with docents from the Los Angeles Conservancy. We'll visit Pershing Square, the city's oldest public park, and climb the stairs of Bunker Hill. Then we will take the Redline to Union Station, the classic train terminal that has been the setting of countless movies, and tour the famous Fred Harvey Restaurant. Wear comfortable walking shoes for our trek into the center of the city. $20 members, $25 nonmembers.

■ THE OTIS CHANDLER MUSEUM

Saturday, February 7, 9 a.m. to noon. Children ages 12 and older welcome if accompanied by an adult

The Otis Chandler Vintage Museum of Transportation and Wildlife in Oxnard celebrates the enthusiasms of a dynamic collector and outdoorsman. In amassing motorcycles, Mr. Chandler has focussed on



PHOTOGRAPHS COURTESY CHARLES FOLEY

Lecture

■ THE ELEPHANTS OF TARANGIRE

Sunday, March 15, 2 p.m., Jean Delacour Auditorium, Museum of Natural History

Many of Tanzania's elephants, which were formerly free roaming, have been compressed into Tarangire National Park because of heavy poaching in the country at large. For the past 4 years, Charles Foley, a Ph.D. candidate from Princeton University, has been investigating the effects of poaching on elephant society, specifically its impact on female behavior and reproduction. Elephants are long-lived, intelligent, and highly social animals, which form small, relatively stable family groups. Poaching destroys the basic fabric of their society, namely the strong relationships among individuals that are built up over many years. Mr. Foley will describe his research on a group of elephants that he has come to know; he will also discuss the specific pressures facing the African elephant and current efforts to conserve these magnificent animals. $7 members, $9 nonmember, $5 students with I.D. Cosponsored by the Los Angeles Zoo.





Harley Davidson and other American brands, but his museum also includes high-performance European and Japanese models and a rapidly growing suite of classic automobiles. On our tour of the Chandler Museum, its General Manager, Glenn Bator, will give the history of the vehicles and also show us other treasures from the collections, including bronze statues, tapestries, wildlife dioramas, and a full-size 1800s Baldwin Steam Locomotive. $30 members, $40 nonmembers

■ PELAGIC BIRDS AND MAMMALS

Sunday, February 15, 7 a.m. to 4 p.m. Children ages 7 and older welcome if accompanied by an adult

The San Pedro Channel abounds with marine wildlife. With museum naturalists Dr. John Heyning and Kimball Garrett, set out for an all-day open-water expedition aboard the Research Vessel *Vantuna* to view the animals found near the sea surface in this biologically rich area. Journeying around and beyond Santa Catalina Island, we'll search for seabirds such as shearwaters, petrels, and jaegers, which ordinarily are found far offshore. At this time of year, gray whales make their way along the Pacific coastline of North America from the calving lagoons of Baja California to the summer feeding grounds of the Bering and Chukchi seas. And we may encounter minke whales, harbor seals, and California sea lions. Bring a bag lunch. $65 members, $75 nonmembers.

CHILDREN'S & FAMILY PROGRAMS

To ensure the best possible experience for your child, please abide by the age requirements stipulated in our program descriptions.

■ GOING, GOING, GONE!

Saturday, January 24, 10 a.m. to noon, Museum of Natural History. Children ages 9 to 12

In the nineteenth century, the dodo bird of Madagascar became extinct: the last known individuals died, and the species disappeared forever. Why should we care? Naturalist and museum educator Carl Carranza

PROGRAMS FOR MEMBERS AND VISITORS CONTINUED

gives some facts about extinction—what causes it and how the end of a species will continue to affect us all. $15 members, $20 nonmembers.

■ DINO-SNORES

Overnight, Saturday, January 31, to Sunday, February 1, 7 p.m. to 8:30 a.m., Museum of Natural History. Children ages 5 and older with accompanying adult

Sleep in the shadows of *Tyrannosaurus* and *Triceratops* on our overnight adventure among the dinosaurs. We'll have a hands-on night of activity as we tour the Dinosaur Hall with some of our favorite museum docents, join museum instructors in a craft project, and listen to stories about ancient reptiles. An evening snack and breakfast are included. Bring a sleeping bag and air mattress. $40 members, $50 nonmembers.

■ THE WOLF

Real or Imagined?

Saturday, February 21, 10 to 11:30 a.m., Jean Delacour Auditorium, Museum of Natural History. Children ages 6 and older with accompanying adult

Come and meet Koani, a 100-pound gray wolf from Montana, and Indy, her dog companion. Wildlife biologist Patricia Tucker will give your family a glimpse into the secret lives of North America's most fascinating predators. Then documentary filmmaker Bruce Weide will share stories from myth and folklore, revealing the wolf that stalks human imagination. $7 members, $9 nonmembers, $5 students with I.D.

■ CRASH WITH THE CARS!

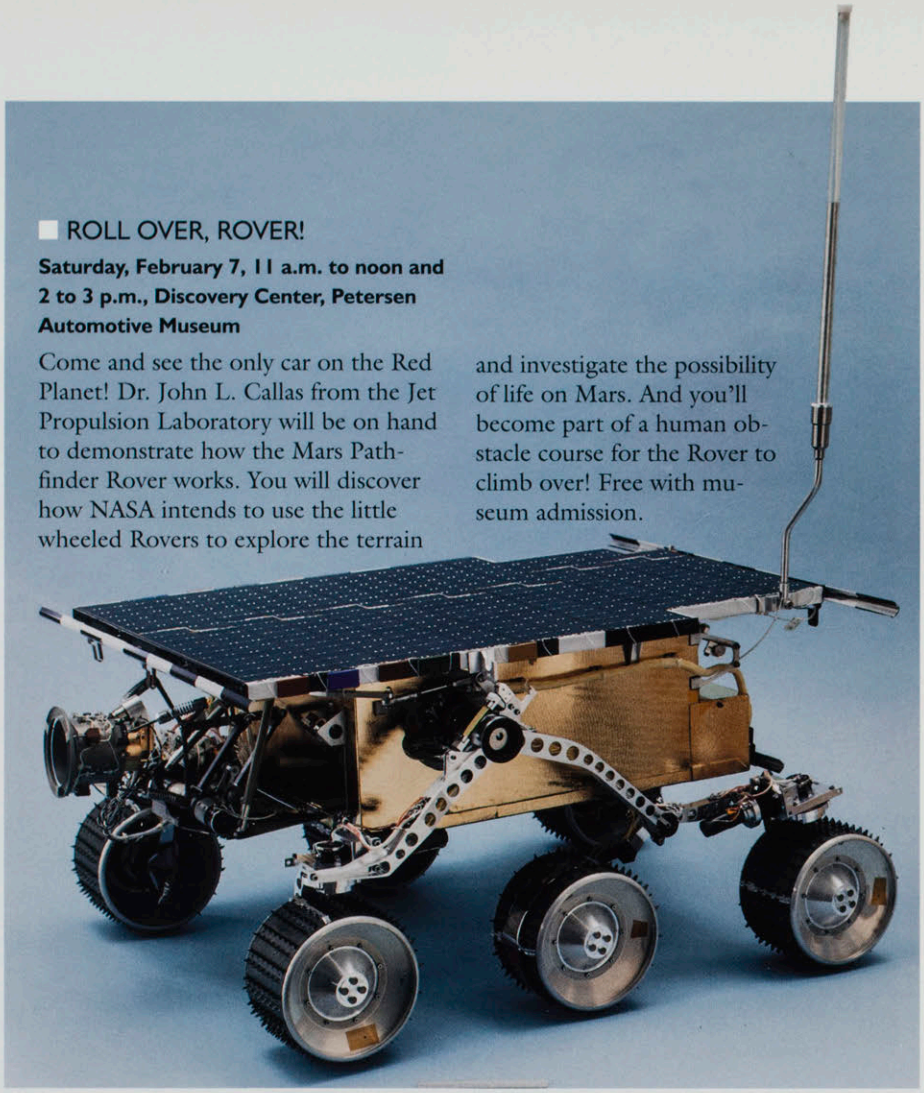
Overnight, Saturday, February 21, to Sunday, February 22, 7 p.m. to 8:30 a.m., Petersen Automotive Museum. Children ages 5 and older with accompanying adult

Make sparks fly in the new May Family Discovery Center. You'll get to take a flashlight tour through the museum's automobile vault and create car crafts to take home as a keepsake of this nocturnal visit to the Petersen. An evening snack and breakfast are included. Bring a sleeping bag and air mattress. $40 members, $50 nonmembers.

■ ROLL OVER, ROVER!

Saturday, February 7, 11 a.m. to noon and 2 to 3 p.m., Discovery Center, Petersen Automotive Museum

Come and see the only car on the Red Planet! Dr. John L. Callas from the Jet Propulsion Laboratory will be on hand to demonstrate how the Mars Pathfinder Rover works. You will discover how NASA intends to use the little wheeled Rovers to explore the terrain and investigate the possibility of life on Mars. And you'll become part of a human obstacle course for the Rover to climb over! Free with museum admission.



COURTESY JPL, CALIFORNIA INSTITUTE OF TECHNOLOGY (JPL 258888c)

■ ARACHNIDS AROUND US

Saturday, February 28, 10 a.m. to noon, Education Classroom, Museum of Natural History. Children ages 8 to 10

Learn about the amazing world of spiders from Insect Zoo educator Sarah Thompson. She will share interesting facts about these eight-legged creatures, give you a special tour of the Insectary, and introduce you to some of the Insect Zoo's spider residents. $15 members, $20 nonmembers.

FAMILY FIELD TRIPS

■ TREASURES OF THE TIDE POOLS

Sunday, March 8, noon to 3:30 p.m. Children ages 5 and older with accompanying adult

Marine biologist and museum educator Traci Watson will introduce your family to the tide pool environments along our coast. We will see the critters that live on and under the rocks and learn what happens to these communities when the tide goes out. Please bring a picnic lunch: we will enjoy some introductory tide pool trivia from Traci prior to getting our feet wet; you will also make a tide pool craft item to take home. $20 members, $25 nonmembers

A family camping trip

■ FOSSIL HUNTING AT RED ROCK CANYON

Friday, March 27, through Sunday, March 29. Open to families with children of all ages

Discover the world of Miocene fossils on this trip to beautiful Red Rock Canyon. We'll search for fossils with museum curator Dr. Dave Whistler, the only paleontologist with a collecting permit for the canyon. We'll also take nature hikes, learn about the unique geology of the region, and roast marshmallows around the evening campfire. Best of all, parents can relax while Helen Whistler prepares all three meals on Saturday as well as breakfast on Sunday. You provide transportation and camping gear, we'll take care of the rest! Arrive anytime after noon on Friday. Members: $65 child, $95 adult; nonmembers: $75 child, $105 adult.

ANNOUNCEMENTS

Now available from your Members' Loan Service

■ AFRICA TEACHING KITS

Two new thematic teaching kits have been added to the Members' Loan Service, to extend the exhibit, *AFRICA: One Continent, Many World*, into your classroom. Hands-on dolls, household items, jewelry, traditional crafts, masks, and musical instruments are supplemented with audio tapes, children's books, and an educator's notebook (with background information, suggested lesson plans, and classroom activities)—all conveniently packed in a traveling trunk.

Visit your Members' Loan Service in the Museum of Natural History to learn about this and all of our other Teaching Kits; while there, you can pick up a full list of the individual science specimens, historical objects and models, and cultural artifacts that are available on loan for classroom enhancement or home study.

For a $5 fee, three individual items may be borrowed for a 2-week period. Teaching Kits rent for $10 for a 2-week period. For more information please call the loan counter, 213/763-3228, during program hours, or the Loan Programs' Coordinator at 213/763-3345. **Program hours: Thursdays, 2 to 4 p.m., and Saturdays, 10 a.m. to 2 p.m.**

FAMILY FUNDAYS

These family programs are free with museum admission for children ages 4 and older. No reservations are necessary, but space in some programs is limited, so please arrive early.

■ ANIMAL LEGENDS

Saturday, January 17, 1:30 p.m., Discovery Center, Museum of Natural History

Join museum educator Alise Arato and explore Native American legends about the animals through storytelling and maskmaking.

■ AFRICAN STORYTELLING AND PERCUSSION

Saturday, February 14, 1;30 p.m., Discovery Center, Museum of Natural History

Darrell Cox will enchant you with his African storytelling; then you'll sing African songs and make your own musical instrument to take home.

■ HALF-GALLON BUS

Saturday, January 31, 2 to 4 p.m., Artopia, Petersen Museum

We'll recycle everyday things and transform them into a toy bus that you can take home. Bring your own milk cartons and bottle tops.

■ RACING IN SPACE

Saturday, February 28, 2 to 4 p.m., Artopia, Petersen Museum

Join us for a flying origami toy workshop. You can decorate your frisbee-shaped toy with car designs and than watch it skim the air, racing in space.

PUBLIC PROGRAMS RESERVATION FORM

■ **By telephone:** Use your MasterCard or VISA. Call the Education Division at 213/763-3534, weekdays, 8 a.m. to 4 p.m. Credit cards are accepted only with a minimum charge of $20.

■ **By mail:** Complete the form below, fill in the charge information or enclose a check payable to Museum Foundation, and return your order form and payment with a self-addressed, stamped envelope. The form may be duplicated. Mail to: ***Education Division, Natural History Museum, 900 Exposition Boulevard, Los Angeles, CA 90007***

■ **Important: Reservation, Waiting List and Refund Policies.** Preregistration is required for all classes, workshops, and field trips and is recommended for all other Education Division programs. Tickets to auditorium events may be purchased at the door on a first-come, first-served basis; seating is not reserved. Reservations are not necessary for Family Fundays. Applicants for filled programs will be placed on a waiting list and contacted if vacancies or rescheduling occur. If you have paid for a filled program, your payment will be refunded in 4-6 weeks.

Cancellations must be made at least 6 business days prior to the first day of an event for the registrant to be eligible for a partial refund. No refunds can be given for cancellations made in the 5 days before the event.

Dates and times of programs are subject to change, and class sizes are limited. Please call 213/763-3534 weekdays between 8 a.m. and 4 p.m. to verify program dates, times, and availability.

■ **Special Assistance Available.** If you wish to attend a museum event and require auxiliary aids or services, please contact the museums' Americans with Disabilities Act (ADA) Compliance Officer at least three (3) business days prior to the event. The ADA Compliance Officer may be reached by telephoning 213/763-3417 (voice) or by calling that number via California Relay Service at 800/735-2929 (TTY).

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Natural History Museum
900 Exposition Blvd.
Los Angeles, CA 90007

❑ My check is enclosed

❑ Charge my credit card:
- ❑ MasterCard
- ❑ VISA

Program	Number of participants	Price	Total Price

Total Remittance _____

Credit Card # _____ Expiration Date _____

Signature _____

Please list children's names, ages, and programs in which they are enrolling:

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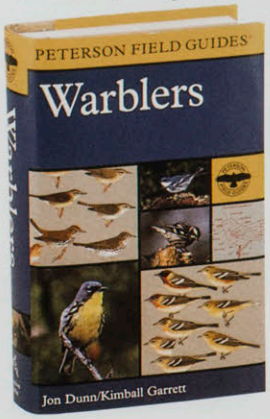
As of November 1, 1997

MUSEUM ON THE MOVE
CONTINUED

continued from page 7

thoritative reference, the book treats 444 species, including all those known from freshwater and nearshore habitats and open-ocean waters within the archipelago. For almost all species the book gives information about natural history, habitat in the Galapagos, and range in the Pacific. The result is an extensively illustrated identification guide for visitors to the Galapagos National Park, a comprehensive reference for scientists, and a basis for future assessment of possible environmental degradation in the islands.

A Field Guide to Warblers of North America (Houghton Mifflin, 1997), the latest volume in the famed Peterson Field Guide series, is the product of more than 10 years of work by field ornithologist Jon L. Dunn and the museum's Ornithology Collections Manager Kimball L. Garrett. All sixty species occurring north of the United States/Mexico border are treated in this guide, which includes 32 color plates, 141 color photos, and detailed distribution maps for each species. Although most North American warbler species are strikingly colorful in plumage, their small size, active behavior, and predilection for treetop foraging or skulking in the underbrush can combine to make field identification a challenge. Armed with this guide, some patience, and tolerance for an occasional bout of "warbler neck," the birder should be able to master the field identification of this important group.



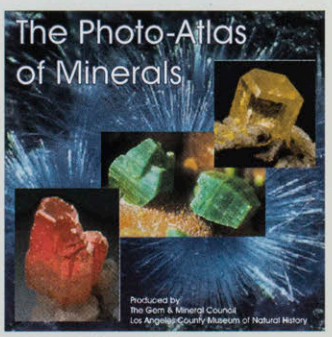
A CD-ROM FOR MINERAL LOVERS

The Photo-Atlas of Minerals, billed as the ultimate photographic reference on the subject, is to be released by the Natural History Museum in the first week in February. The museum's Gem and Mineral Council is the producer of the CD-ROM, which was developed by Dr. Anthony R. Kampf, Curator of Mineral Sciences, and Dr. George Gerhold of Western Washington University.

The CD-ROM features more than 6,000 high-resolution color images of minerals, including several thousand by noted mineral photographer Dr. Wendell E. Wilson and thousands of microscope images provided by Louis Perloff, a highly respected micromineral collector and photographer. The disk also contains a number of scanning electron microscope views.

The new product contains descriptive information on all known minerals, audio guides to name pronunciations, information on uses and on the origins of names, an extensive hyper-linked glossary of terms, a modern classification scheme, and cross-indexing for searching on many different criteria. Not only can you copy and print images and data, but you can also create Windows wallpaper and slide shows on your computer screen.

The Photo-Atlas of Minerals is available only for PC-compatible systems equipped with Windows; the price is $49.95. Watch for the CD-ROM in the Museum Shops, or contact the Gem & Mineral Council (213/763-3326) for additional details.



A WORLD OF SPIRIT

On September 22, the Museum of Natural History in Exposition Park welcomed as volunteers-for-the-day fifty staff members—including partners, principals, managers, and accountants—from the local offices of KPMG Peat Marwick. The employees were participating in a national day of cummunity work in celebration of the company's 100th anniversary. Among

the museum operations to benefit from the volunteers' tireless enthusiasm were Anthropology, Ornithology, Crustacea, Echinoderms, Ichthyology, Mineral Sciences, Vertebrate Paleontology, Exhibits, Education, and Finance.

DONORS & MEMBERS NEWS

MUSEUM LEADERS: THE FELLOWS

The Fellows are individuals who support the Natural History Museum at the highest level, with annual gifts of $1,000 or more. One of the privileges of membership is the opportunity to participate in a variety of exciting programs and field trips with naturalists, historians, and other experts who are leaders in their fields. The Fellows often gather in members' homes, in intimate settings that provide for easy exchange of ideas between speakers and guests.

We would be delighted to invite you to a upcoming event so that you can experience the pleasures of belonging to the Fellows firsthand. Please contact Kathleen Copus, Coordinator of Support Groups, at 213/763-3307, for information regarding the winter/spring schedule of adventures planned for this distinguished group.

JOIN THE FIVE STAR FAMILIES!

The Natural History Museum's Five Star Families participate in an exclusive array of fun-filled, enriching activities for children and adults. In the coming months, members of this museum support group will have breakfast in the exhibit *Dinosaurs;* other planned events are a talk and book signing with a children's book author, special behind-the-scenes tours, off-site field trips, and visits with museum curators.

Membership in Five Star Families is $100 annually in addition to the regular membership fees at the Family level ($50) and above; for further information, please call the Development Office at 213/763-3307

1998 DINOSAUR BALL

Join us for an elegant evening on Saturday, March 14, when the Natural History Museum's Alliance Board of Directors hosts its Sixteenth Annual Dinosaur Ball. The black-tie fundraising gala will again be held in the beautiful halls of the Exposition Park building, where you will dine and dance among the "Treasures of the Museum." Tickets are $300 per person, with proceeds benefitting the museum's programs. For more information, please call 213/763-3307.

TAX DEDUCTIBILITY OF MEMBERSHIP DUES

The tax deductible amounts for some of our Membership levels have changed to reflect the value of new benefits. For further information, please contact your tax advisor.

Level	Membership Dues	Tax Deductible Amount
Active	$40	$40
Educator	$40	$40
Family	$50	$50
Contributing	$100	$90
Patron	$150	$105
Naturalist	$250	$205
Explorer	$500	$430

Yvonne Brathwaite Burke, Los Angeles County Supervisor, Second District *(left)*, with Marilyn F. Solomon, Natural History Museum Governor and Trustee (*center*), and Deborah L. Mack, at the October 7 opening of the exhibition *Africa: One Continent, Many Worlds.*

Dr. Mack is academic consultant for the traveling Africa exhibit and was project director and senior developer of the Field Museum's permanent installation on the subject. While in Los Angeles for the Natural History Museum's opening of the exhibition, Dr. Mack gave the keynote speech to more than 430 elementary and secondary school teachers who attended the museum's educators' preview; she also led tours for docents and staff members and oversaw the final details of the exhibit's installation.



In addition to the October 7 event, the museum also hosted a Saturday morning members-only viewing, which was attended by more than 450 people.

Africa: One Continent, Many Worlds, was sponsored by the Ford Motor Company and the following Ford Divisions: Ford Dealers, Lincoln Mercury Dealers, Ford Credit, Ford Customer Service, and Visteon.

Other sponsors were the Los Angeles Metropolitan Transportation Authority, Ralphs/Food 4 Less Foundation, Target Stores, WAVE Community Newspapers, KACE Radio 103.9 FM, Hyatt Hotels, and America West Airlines.

The Natural History Museum exists to advance knowledge and to enable people of all ages, backgrounds, and interests to understand and appreciate their natural and cultural heritage. The museum assembles, conserves, interprets, and holds in trust collections of irreplaceable objects from nature and human history. These collections reveal the history of the Earth and the evolution and diversity of life and culture. They sustain programs of research, exhibits, education, and publication.

Natural History Museum of Los Angeles County
World Wide Web: http://www.nhm.org

■ Museum of Natural History, Exposition Park
900 Exposition Blvd., Los Angeles 90007
General information 213/763-DINO

■ George C. Page Museum of La Brea Discoveries
5801 Wilshire Blvd., Hancock Park, Los Angeles 90036
General information 213/934-PAGE

■ Petersen Automotive Museum
6060 Wilshire Blvd., at Fairfax, Los Angeles 90036
General information 213/930-CARS

■ William S. Hart Museum
24151 San Fernando Road, Hart Park, Newhall 91321
General information 805/254-4584

Notice for materials in alternate format. If you require *Terra* or other printed information about the museums in an alternate format, please contact the museums' Americans with Disabilities Act (ADA) Compliance Officer at 213/763-3417 (voice) or by calling that number via California Relay Service at 800/735-2929 (TTY)

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Exposition Park, Los Angeles, California 90007

DINOSAURS

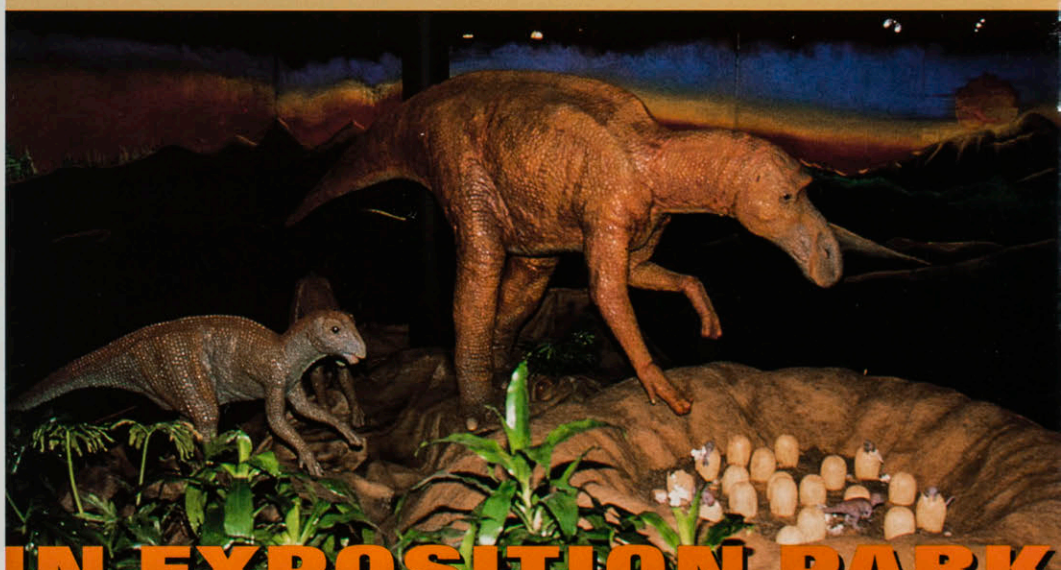


The Museum of Natural History is pleased to present *Dinosaurs*, an exciting exhibit featuring fourteen animated sculptures of everyone's favorite extinct animals set in lifelike habitats. Through the wizardry of their creators, the Kokoro Company of Japan, the robotic beasts move, stomp, and roar just as they did more than 65 million years ago.

The noisy activity of the Kokoro creatures—and displays of real fossils from the museum's collections—dramatize the latest scientific thinking about dinosaur appearance and behavior and provide a thrilling adventure for museum-goers of all ages.

Dinosaurs, on view January 23 through May 17, Museum of Natural History, Exposition Park. For exhibit information, please call 213/763-DINO.

Visit the museum's permanent Dinosaur shop, and a special Gallery Dinosaur Store, for educational toys and games, books, and videos that bring the "thunder lizards" to life again! For shop information, please call 213/763-3488.



IN EXPOSITION PARK